IV&V project assessment process validation

Method: map the Space Launch System SRR/SDR IV&V findings to

IV&V PBRA

IV&V RBA

IEEE 1012-2004 Scorecard

*Reference: All graphics from SLS Industry Day

IV&V project assessment
Process Validation Presentation

- Presenters
  - Stephen Driskell
  - Team Members for Questions

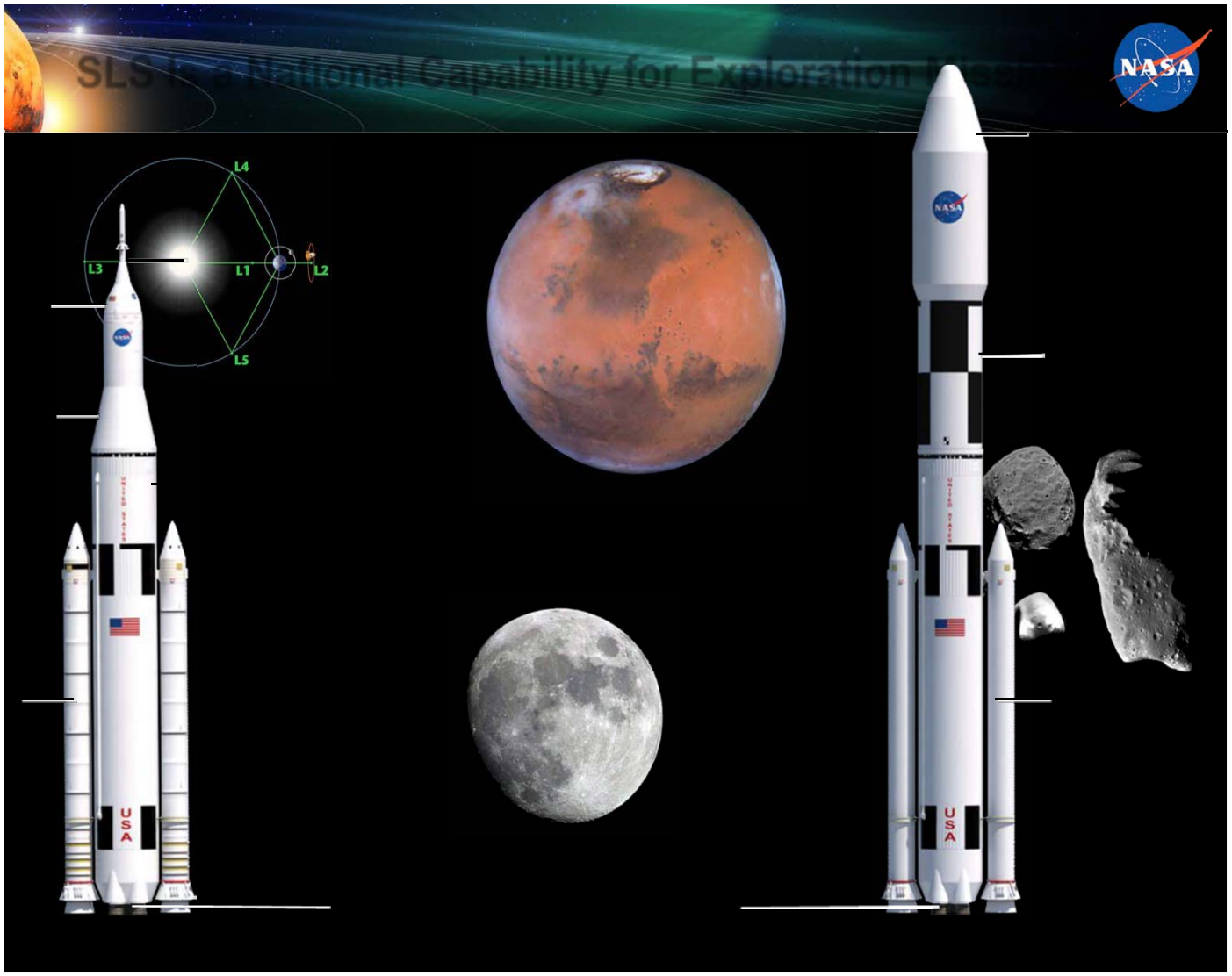
Study support from

- Rich Wolf, HEO ESD IV&V Deputy Project Manager
- Christina Moats, HEO ESD IV&V Project Manger

NASA IV&V SLS Topic & Participants

- **Abstract**: The Space Launch System (SLS) will launch NASA's Multi-Purpose Crew Vehicle (MPCV). This launch vehicle will provide American launch capability for human exploration and travelling beyond Earth orbit. SLS is designed to be flexible for crew or cargo missions. The first test flight is scheduled for December 2017. The SLS SRR/SDR provided insight into the project development life cycle. NASA IV&V ran the standard Risk Based Assessment and Portfolio Based Risk Assessment to identify analysis tasking for the SLS program. This presentation examines the SLS System Requirements Review/ System Definition Review (SRR/SDR), IV&V findings for IV&V process validation correlation to / from the selected IV&V tasking and capabilities. It also provides a reusable IEEE 1012 scorecard for programmatic completeness across the software development life cycle.
- Two teams performed separate concurrent assessments
  - IV&V Participants in the SLS SRR/SDR
    - Melvin Rother, Bimal Patel, Vaughn Harvey, Stephen Driskell, Thomas Marshall, Gary Barber, James Chamberlain, and Noble Nkwocha,
  - IV&V Participants in the RBA and PBRA
    - Van Casdorph, John Bradbury, Rodger Barrington, David Frazier, James Dell, Richard Wolf, and Kimberly Mittelsted,

SLS Missions Summary



Exploration Missions For Earth and Moon to Asteroids Mars & Mars Moons

Initial Capability 70 mt in 2017 to Evolved Capability 130 mt Cargo

SRR/SDR IV&V results

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- *All of these Pre-RIDS and RIDS fall into one of three categories:*
  - *IV&V issues Accepted as RIDS* *7*
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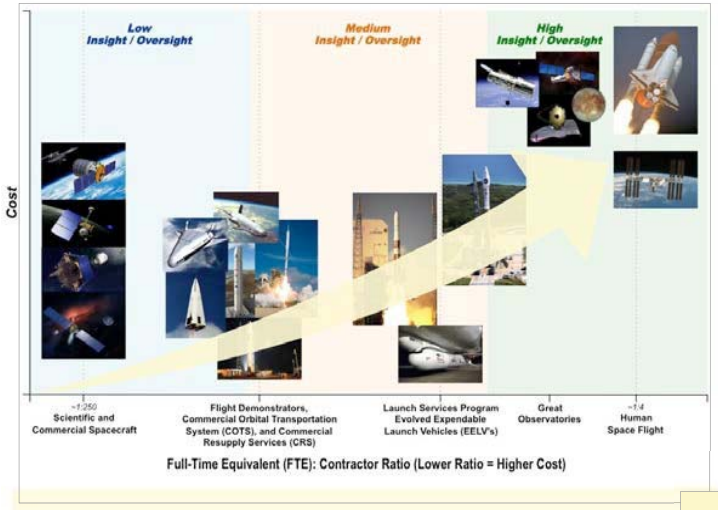
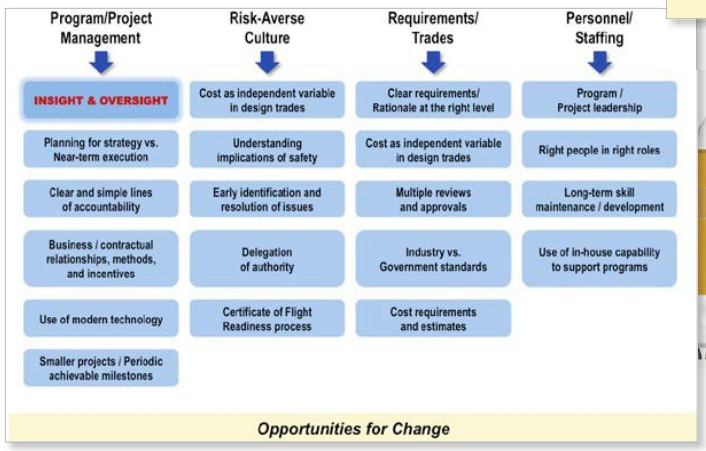
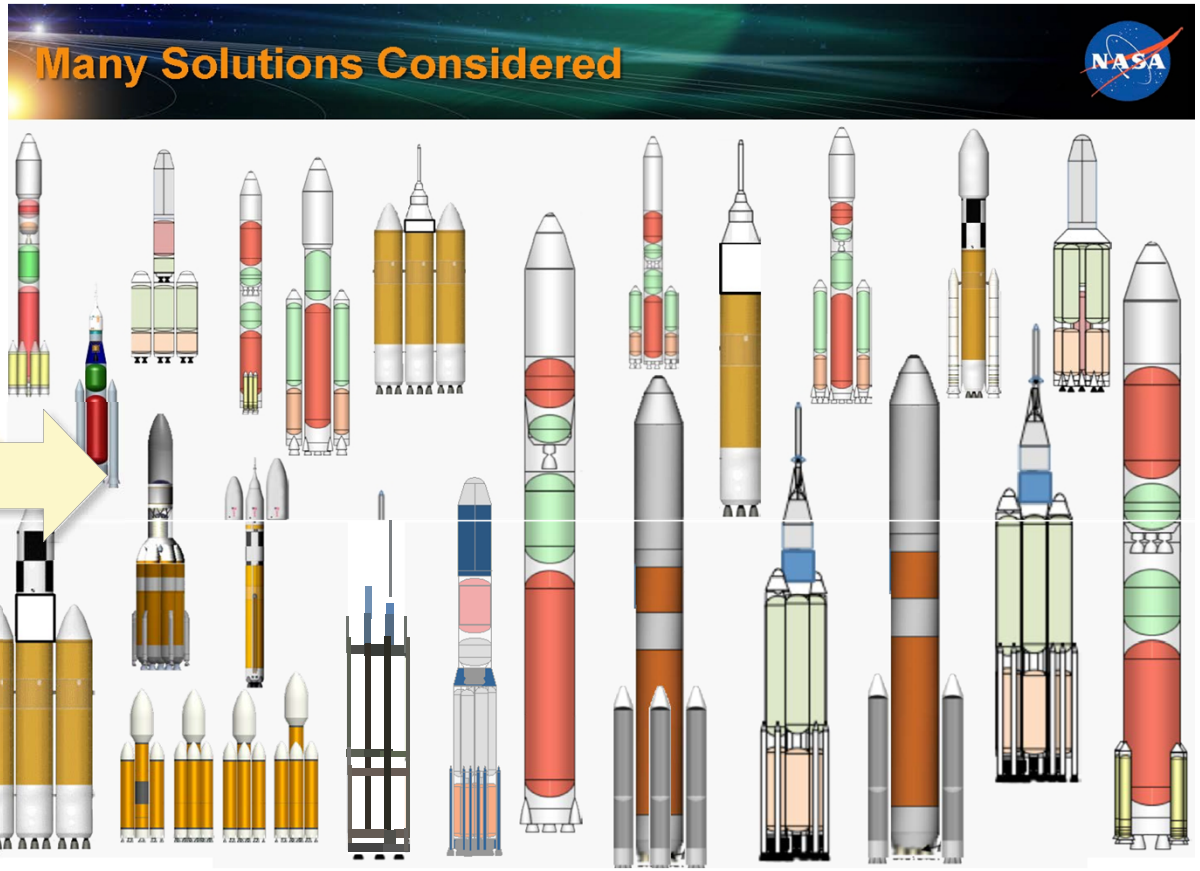
- IEEE 1012 - there is a GOOD correlation from SRR/SDR IV&V RIDs and Pre-RIDs to the SRR/SDR Software Life Cycle to the IEEE 1012 Software Validation and Verification Standard - 2004

SLS Affordability Tenets & Options

Boosters, Stages, Engines, Spacecraft & Fairings,
Advanced Development + Existing Capabilities

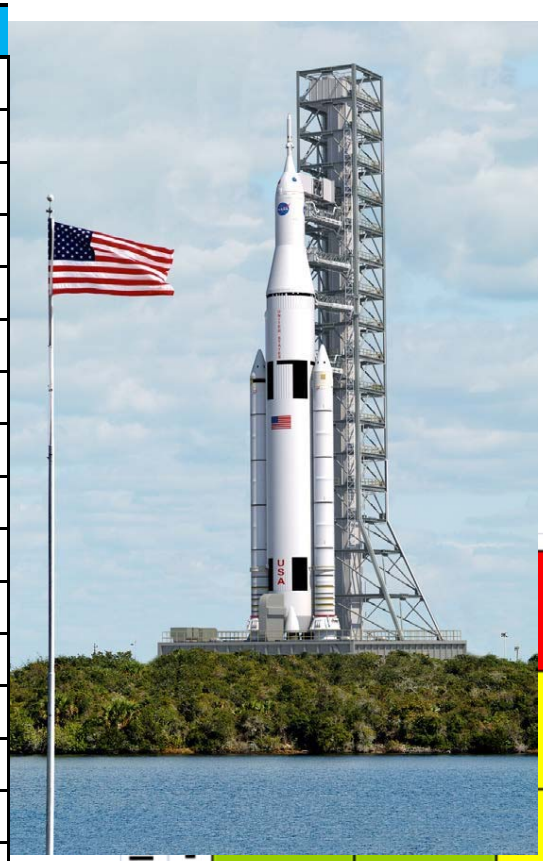


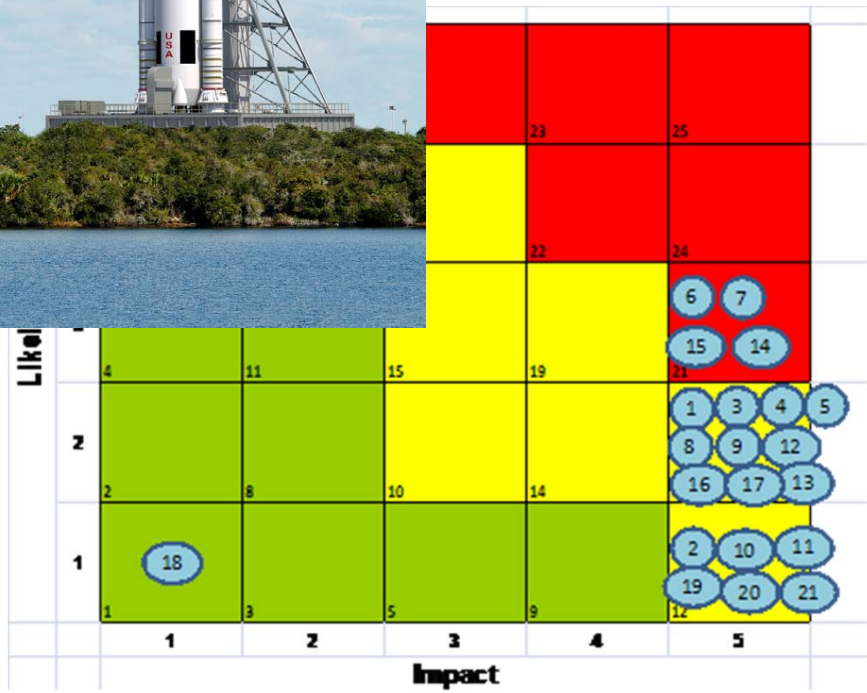




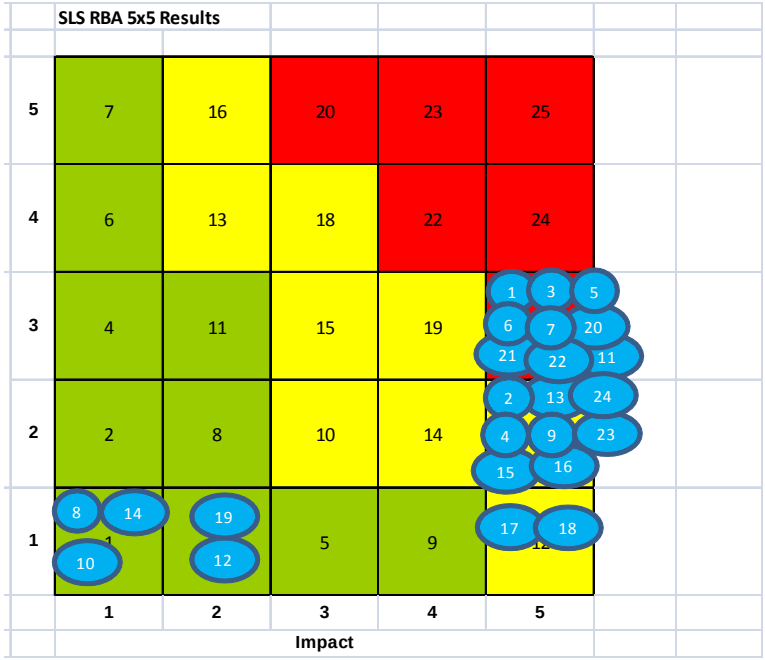
PBRA Map to IV&V SRR/SDR Results

ID	RIDs only	Pre-RIDs	Capability
SLS1	1	2	SLS.Provide Health & Status data
SLS2			SLS.Provide Caution & Warning data
SLS3			SLS.Provide Fault Detection
SLS4			SLS.Provide Fault Isolation
SLS5			SLS.Provide Fault Recovery
SLS6	7	8	SLS.Perform Vehicle State & Mode Management
SLS7	1	4	SLS.Perform GNC
SLS8			SLS.Manage Subsystem Power
SLS9		1	SLS.Manage Flight Termination System
SLS10		5	SLS.Perform Required Abort Sequence
SLS11			SLS.Control Boosters
SLS12			SLS.Control RS-25 Engines
SLS13		2	SLS.Control iCPS Engine
SLS14		2	SLS.Control CPS Engine
SLS15	1	4	SLS.Control J-2X Engines
SLS16	1	3	SLS.Track Ascent Operations
SLS17			SLS.Provide CMD Validation & Acceptance
SLS18			SLS.Provide onboard command history
SLS19		1	SLS.Provide Data to Ground
SLS20		1	SLS.Provide Data to MPCV
SLS21			SLS.Provide stage break-up and sinking upon impact
Total	11	33	





RBA To IV&V SRR/SDR



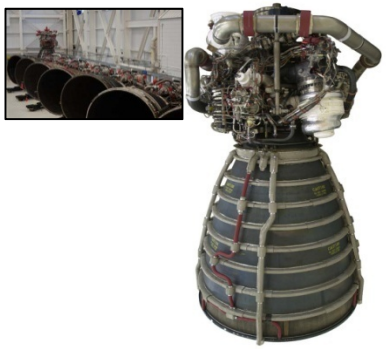
ID	RIDS only	Pre-RIDs ***	Entity
1		3	Guidance, Navigation & Control
2		1	Thrust Vector Control
3		2	Real Time Operating System
4			Hardware I/O
5	2	4	M&FM - Mission Manager
6		4	M&FM - Abort Manager
7			M&FM - Flight Computer Redundancy Manager
8			Special Test Application Software
9			CTC ApplicationSoftware
10			Development Flight Instrumentation
11		N	Redundant Inertial Navigation Unit
12			Camera Controller Unit / Imaging System
13			Core Stage Power Distribution & Control Unit
14	1	1	Data Acquisition Control Unit
15		1	Core Stage Engine Control Unit
16			Rate Gyro Assembly
17	1	4	Flight Safety System
18		1	Data Acquisition & Recording Unit
19			Engine Data Acquisition Unit
20		N	DOLILU
21	4	4	Flight Design
22	3	5	Mission Execution & Flight Ops
23		2	Upper Stage Engine Control Unit
24		1	1553 I/O
Total	11	33	

N – Not evaluated in SRR/SDR

IV&V SLS Results MAP to IEEE 1012-2004

IEEE 1012-2004 Standard for Software Verification and Validation	SLS Artifact #1	SLS Artifact #2	SLS Artifact #3	IV&V Pre-Rid & RID	References
1. Overview					
2. Referenced documents					
3. Definitions					
4. Software integrity levels					
5. Software V&V processes					
5.1 Process: Management					
5.1.1 Activity: Management of V&V					
5.2 Process: Acquisition					
5.2.1 Activity: Acquisition support V&V					
5.3 Process: Supply					
5.3.1 Activity: Planning V&V				1	V&V plan, testing & risk criteria not defined
5.4 Process: Development				1	SDR/SRR artifact maturity
5.4.1 Activity: Concept V&V				1	CONOPS - Engines & Stages 1001
5.4.2 Activity: Requirements V&V				26	Requirements
5.4.3 Activity: Design V&V				1	upper stage sensor missing
5.4.4 Activity: Implementation V&V					
5.4.5 Activity: Test V&V				1	Vehicle Management Spec: missing verification, clarify role
5.4.6 Act:Installation and checkout V&V					
5.5 Process: Operation					
5.5.1 Activity: Operation V&V					
5.6 Process: Maintenance					
5.6.1 Activity: Maintenance V&V					
6. Software reporting requirements					
6.1 V&V reports					
6.2 V&V administrative requirements					
6.3 Documentation requirements				1	Architecture
7. Software V&V plan outline				1	Verification Activities
Annex A Mapping tables					
Annex B risk based integrity level scheme					
Annex C IV&V types					
Annex D V&V of reuse SW					
Annex E V&V measures					
Annex F Organizational relationship					
Annex G Optional V&V tasks					
Algorithm analysis.					
Regression analysis and testing.					
Reuse analysis.					
Simulation analysis.					
Sizing and timing analysis.					
Total				33	

- SRR/SDR IV&V findings
- Mostly Requirements
- Some Findings on
  - Architecture
  - Verification
  - CONOPS



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WRAP UP

- **NASA IV&V Process for RBA and PBRA supports the capabilities for selecting analysis targets to support SMA and national objectives for the**

SLS Innovative New Business Model

- **Based on the SRR/SDR Findings IV&V will revisit the PBRA/RBA rationale for**
  - **Perform Required Abort Sequence**
  - **Track Ascent Operations**
  - **Flight Safety System**
  - **Provide Health and Status Data**
- **Study shows good validation for the PBRA and RBA priorities established by the NASA IV&V IPEP process**
- **Study shows good validation for the SLS NASA life cycle activity with accepted RIDS on Launch Vehicle (LV):**
  - **Launch Vehicle to SW Functional Allocations Missing**
  - **Safety Critical SW not identified**
  - **V&V Testing and Risk Criteria not complete**